PROTOSOLAR CLOUD COLLAPSE AND REDISTRIBUTION OF ^{26}AL

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Introduction: Ca-Al-rich inclusions (CAIs), chondrules and matrix in individual chondrites are diverse in thermal history and isotopic compositions [1]. Isotopic analysis, in particular Al-Mg systematics, suggests a short interval of formation for CAIs, in the order of ~150 kyr, from precursor condensates that may have formed in an even shorter interval of time [2-4]. The retrieved timescales are comparable with those of the collapse of a cloud parental to a protoplanetary disk [5] and suggests that the oldest chondrite components formed during that epoch. Following the work of [6,7], [8] studied the distribution and thermal alteration of dust (of different chemical compositions) during their transport from the collapsing cloud to the forming disk, and found extensive evaporation of infalling matter, recondensing in condensates, many of which were advected toward the outer disk and mixed with unprocessed dust, in agreement with the compositional gradient for major families of chondrites [1] and the old age of CAIs. However, the widely used Al-Mg chronology [4] is predicated on the uniformity of the ^{26}Al/^{27}Al ratio, which is called into question by apparently old yet ^{26}Al-poor CAIs such as FUN CAIs [9]. This suggests that the parental cloud was itself heterogeneous in ^{26}Al, hence the importance of investigating the distribution of different reservoirs of ^{26}Al within the cloud and the transport and incorporation of ^{26}Al in the Solar System solids that populate the forming disk.

Method: We [10] use the model presented in [8], and study how different ^{26}Al-distributions within the collapsing cloud are redistributed in different refractory dust components (CAIs and bulk material) in the forming disk. In terms of the ^{26}Al/^{27}Al ratio, we considered both a monotonic zoning (with a plateau) and a spike profile, both reaching a maximum around t = 80 kyr consistent with the timescale of CAI production [8]. Our 1D disk model includes several processes such as gas and dust condensation/evaporation, dust growth/fragmentation, radiative and viscous heating, dead zone and cloud infall in the form of a source term [8].

Results: We find that CAIs essentially inherit the ^{26}Al/^{27}Al ratio of the matter infalling at the time of their formation, so that variations of ^{26}Al/^{27}Al among FUN and normal CAIs can be accounted for, without requiring any supercanonical reservoir anywhere. The prevalence of a canonical ratio among normal CAIs, the fact that bulk chondrites show a near-canonical ^{26}Al/^{27}Al ratio, and the ^{26}Al level required for the differentiation of the first planetesimals suggest a scenario where ^{26}Al sharply rose relatively close to the center of the protosolar cloud and essentially remained at a high level outward (rather than having decreased since). As the ^{26}Al abundance would be relatively homogeneous after cessation of infall, this would warrant the use of the ^{26}Al-^{26}Mg chronometer from the formation of normal CAIs onward, to chondrules and chondrite accretion.

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